NBS TECHNICAL NOTE 891

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Issues in Fire Vehicle Replacement: Users' Views and Synthesis

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards [1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau consists of the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Institute for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of the Office of Measurement Services, the Office of Radiation Measurement and the following Center and divisions:

Applied Mathematics — Electricity — Mechanics — Heat — Optical Physics — Center for Radiation Research: Nuclear Sciences; Applied Radiation — Laboratory Astrophysics [2] — Cryogenics [2] — Electromagnetics [2] — Time and Frequency [2].

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement, standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; and develops, produces, and distributes standard reference materials. The Institute consists of the Office of Standard Reference Materials, the Office of Air and Water Measurement, and the following divisions:

Analytical Chemistry — Polymers — Metallurgy — Inorganic Materials — Reactor Radiation — Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations leading to the development of technological standards (including mandatory safety standards), codes and methods of test; and provides technical advice and services to Government agencies upon request. The Institute consists of the following divisions and Centers:

Standards Application and Analysis — Electronic Technology — Center for Consumer Product Technology: Product Systems Analysis; Product Engineering — Center for Building Technology: Structures, Materials, and Life Safety; Building Environment; Technical Evaluation and Application — Center for Fire Research: Fire Science; Fire Safety Engineering.

THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in improving cost effectiveness in the conduct of their programs through the selection, acquisition, and effective utilization of automatic data processing equipment; and serves as the principal focus within the executive branch for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Institute consists of the following divisions:

Computer Services — Systems and Software — Computer Systems Engineering — Information Technology.

THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal Government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System; provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data — Office of Information Activities — Office of Technical Publications — Library — Office of International Relations — Office of International Standards.

---

[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

[2] Located at Boulder, Colorado 80302.

Issues in Fire Vehicle Replacement: Users' Views and Synthesis

P. B. Saunders, R. H. F. Jackson,
P. R. Meyers, and M. H. Pearl

Applied Mathematics Division
Institute for Basic Standards
National Bureau of Standards
Washington, D.C. 20234

A technical report prepared for the
Center for Fire Research
Institute for Applied Technology
National Bureau of Standards
Washington, D.C. 20234

U.S. DEPARTMENT OF COMMERCE, Rogers C. B. Morton, *Secretary*

James A. Baker, III, *Under Secretary*

Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology*

U.S. NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

Issued January 1976

National Bureau of Standards Technical Note 891

Nat. Bur. Stand. (U.S.), Tech. Note 891, 19 pages (Jan. 1976)

CODEN: NBTNAE

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1976

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(Order by SD Catalog No. C13.46:891). Price $1.10 (Add 25 percent additional for other than U.S. mailing).

TABLE OF CONTENTS

ISSUES IN FIRE VEHICLE REPLACEMENT: USERS' VIEWS AND SYNTHESIS

P. B. Saunders
R. H. F. Jackson
P. R. Meyers
M. H. Pearl

ABSTRACT

This report documents the findings and recommendations from a study of fire vehicle replacement procedures. Exploration of that subject proved to require consideration of related issues arising in: (1) writing apparatus specifications, (2) maintaining and repairing vehicles, and (3) obtaining spare parts. The topics and most of the recommendations described herein are synthesized directly from visits and/or telephone interviews with fire department officials across the country. The recommendations of the study call for greatly increased communication among departments, the development of standards for vehicle performance, maintenance staff size, etc., and national and/or regional centers for training personnel and establishing standard vehicle testing procedures.

Key words: Engine pumper; fire vehicle; ladder truck; maintenance; replacement; specifications; standards.

I. INTRODUCTION

This report documents an exploration[1] of the policies and procedures used by fire departments in their replacement of pumpers and trucks. Wide variations in these policies and procedures were found, reflecting both their relationships with other aspects of overall fire department operation and the substantial differences, nationwide, among local government structures and regulations. Despite these variations, it proved possible to identify several broad areas perceived commonly as "problems"; such identification was a major goal of our effort.

How vehicle replacement is or should be carried out depends on a number of other elements in a department's activities. Proposed innovations or improvements in replacement policies cannot be evaluated without considering both what options are available in these other aspects of departmental operation, and how much control over replacement the fire department is given by the jurisdiction it serves. This report is intended to illuminate and emphasize the options for change and to indicate areas for practical improvement. It is hoped that our articulation of difficulties and potential remedies will stimulate further thought and discussion by members of the fire services, both within individual departments and on a nationwide interdepartmental level, leading ultimately to resolution of at least some of the apparatus-related problems associated with fire protection.

Equipment replacement problems have a long history in industrial engineering and operations research. In an earlier paper [1][2], fire vehicle replacement was studied on an idealized mathematical basis comparing the trade-off between (a) avoidance, through early replacement, of older vehicles' increasing maintenance costs, and (b) the cost of purchasing new vehicles. Although interesting from a theoretical standpoint and as a framework for analytical discussions, the model developed in that early study is not directly applicable for use by most fire departments today. Nevertheless, its announcement generated inquiries and expressions of interest from numerous officials of fire

---

[1] Sponsored by the National Bureau of Standards' Fire Service Technology Program (head: Dr. B.M. Levin), a part of the Bureau's Programmatic Center for Fire Research (head: Dr. J.W. Lyons). During the course of the project, sponsorship was transferred to the National Fire Prevention and Control Administration.

[2] Numbers in brackets indicate references listed in Section VI of this report.

departments and city administrations, thus indicating considerable and widespread concern over fire vehicle replacement problems. These requests stimulated initiation of the current study, to examine more closely the nature of the fire vehicle replacement "scenario" with the aim of identifying its less satisfactory aspects and arriving at practical recommendations for dealing with them.

Our approach was to systematically collect information about all facets of vehicle replacement through interviews with numerous fire department officials. In addition to contacting most of the fire departments that had expressed interest in the earlier study [1], members of the project team spoke by phone and/or in person with officials from additional fire departments chosen to secure a wider geographical distribution across the country. Discussions were conducted with a total of 30 departments, and about half of these were visited; those contacted ranged in size from large city to small town, and in location represented both coasts, the far Northwest, the Southwest, the South, the Midwest, the Rocky Mountain Area, and New England.(3)

We want at this point to acknowledge with appreciation the hospitality, cooperativeness, and warm interest accorded our visits by fire department staffs (both chiefs and subordinates), as well as the similar responsiveness typical of those we could "visit" only via the impersonal medium of the telephone. The importance of such a reaction, for a study such as this, will be obvious to the reader. Many fire chiefs took the opportunity offered by our interview to discuss the principal problems they saw confronting them, often in a context broader than the "vehicle replacement" theme governing this study.

A limitation of the study's scope is made evident in the title of this report. We have served mainly as reporters and synthesizers of fire departments' views as to the nature and relative importance of the various replacement-related problems which face them. Our information-gathering sessions were relatively brief; no independent observations or verifications were undertaken; the (possibly) distinctive views and insights of fire vehicle manufacturers and city managements were not solicited.(4) We therefore do not consider ourselves entitled to adopt (and hope to have avoided), in what follows, the dogmatic tone of "instant experts".

At the present time, guidelines range from a 10 year replacement policy in New York City (where engine companies respond to as many as 25,000 alarms by the time of replacement), to policies of keeping vehicles in good operating condition as long as possible, sometimes as long as 30 to 35 years. However, the policy most frequently encountered is that referred to in Municipal Fire Administration [2] which states, "Pumpers will probably last an average of 15 to 20 years; ladder trucks, 20 to 25 years, plus a reserve service of about 5 years." Even though the book goes on to make allowances for situations in which other replacement policies are appropriate, it seems to be the single sentence quoted above which many fire departments feel is imposed too rigidly by city budget officials. This study should clarify the need for, and possible directions of, more flexible guidelines.

The predominant opinion of the fire officials interviewed is that the expected vehicle life called for in the above policy is far too long. One responding department, however, is required to assume an even longer expected vehicle life, and would be delighted to obtain replacements according to the above policy. On the other hand, several other departments felt "pressured" to comply with this standard because of its influence on underwriters' ratings, even though they feel capable of maintaining in good condition vehicles older than the recommended age. The disparity of these two situations becomes understandable when traced to differences in other aspects of the overall fire department operation.

Section II, below, gives an overview of vehicle replacement. Sections III-IV present in some detail discussions of various factors directly involved in the replacement process as well as other elements of the total operation which affect replacement decisions. Suggestions, recapitulated in Section V, are made for possible improvements in several areas.

---

(3) Alaska and Hawaii are not represented.

(4) Solicitation of these views would be a natural follow-up to the present study.

II. FIRE VEHICLE REPLACEMENT: AN OVERVIEW[5]

In an ideal vehicle replacement process, one would rationally decide that a vehicle needed to be replaced, and then proceed to replace it directly thereafter. Unfortunately, for many reasons fire departments are not free to operate in this ideal manner.

In practice, replacement is indicated if a vehicle is irreparably broken down, or is thought to be undependable,[6] or if its cost of repairs becomes too high, or if it breaks down too often. Except possibly in the first case, however, a subjective judgment is required to determine how much is "too high" or "too often". Furthermore, a vehicle may be regarded as "irreparably broken down" simply because parts needed for repair are not available, even though the "fix" itself would be relatively minor were the proper materials at hand.

A second complication concerns the part of the replacement process which comes after the decision to replace has been made.[7] There is typically a long delay between deciding on replacement and being able actually to put a new vehicle into service (currently the manufacturer's delivery period alone is 18 to 24 months!), yet service must be maintained in the interim. Here the difficulties can be divided into two general categories:

1. Funds for replacement must be committed. This required both the availability of funds in the municipal government and the ability to convince the relevant funding agents of the need for replacement.

2. Specifications must be written, bids must be made and accepted, orders must be written, and finally the vehicle must be delivered and tested prior to being placed in active service.

These two areas of complication, deciding to replace and replacing, are closely related. For example, if the post-decision part of the replacement process itself can take three years, then it is obviously not feasible to wait for total breakdown to occur before beginning a replacement action. On the other hand, the further a vehicle is from total breakdown, the more difficult it is to convince others that replacement is needed. This dilemma points up the need to set up a systematic policy for replacement. Development or revision of such a vehicle replacement policy should consider all relevant aspects of the replacement process, including alternatives to replacement.

A formal replacement policy serves the following important purposes.

1. It is a plan designed to avoid being underequipped while waiting for replacements to arrive and enter service. By ordering a new vehicle sufficiently in advance of the need for it, there will always be a full fleet of first line vehicles.

2. It is a way to help avoid unexpected "clustering" of replacements in time by distributing purchases more evenly. This reduces the likelihood of a large strain on the budget being concentrated during a short time period.

---

[5] The entire discussion is phrased in terms of replacement rather than increasing the working fleet of vehicles; however, much of the text is relevant to the latter objective as well.

[6] Some departments will not repair a vehicle that has suffered a severe collision, for fear that there might be invisible damage which could cause a failure at a time of critical stress.

[7] This sharp division of the replacement process into two phases is somewhat oversimplified, but will be retained for purposes of clearer discussion.

3. It eliminates repeated arguments over essentially the same issues at each new replacement incident, thereby lifting an unnecessary burden from personnel both in the fire department and in the municipal comptroller's office.

4. For cities in which replacements are supported by bond issues, the details of a formal replacement policy should influence the terms of the bonds. Often replacements can occur only at the time of a bond issue, which can be as infrequent as every 3 to 5 years. Under these conditions it is especially important to have an estimate of how many of each type of vehicle will need to be replaced prior to the next bond issue, so that the amount of the current issue will be sufficient to cover the required purchases. Furthermore, if vehicles bought with bond money cannot be replaced until the bonds are paid off, then the expected vehicle life should be considered in setting the terms of the bonds, i.e. prior to the bond issue.

These advantages of a formal replacement policy should make evident the need for such a policy, and emphasize that the considerable care and effort required for its development are warranted.

III. THE REPLACEMENT DECISION

Except for the obvious case when the vehicle simply cannot be made to operate, deciding when to replace it is not a simple matter. If the decision must be defended and justified to others, supporting evidence will be useful and may be required. Such evidence, which should also play a role in making the decision in the first place, may consist of the following information:

(i) data describing the present condition of the vehicle in question, and its history of repair and reliability,

(ii) data describing the future performance of vehicles which were at one time in the same condition,

(iii) a list of alternatives to outright replacement which have been considered plus the reasons for their rejection.

This section will discuss some of the possible alternatives, and describe the types of data and analysis which pertain to the replacement decision.

A. Repowering and Rebuilding. One obvious alternative to immediate replacement is that of rebuilding vehicles. In some cases it may be cheaper to repower a vehicle, even to install a new transmission and perhaps a new pump for a pumper, than to buy a new vehicle. In fact, if the body and frame are intact one might (as at least one department has done) build an otherwise "new" vehicle for a fraction of the cost of replacement. To accomplish this, however, one needs an extensive maintenance facility, available either in-house or under contract, fully staffed and adequately equipped for large scale repair and maintenance work. Naturally, the economic justification for an in-house facility of this type increases with the size of the department. In smaller departments where the need to rebuild would occur rarely, such an extensive in-house facility is impractical.

More common than complete rebuilding is the practice of repowering or replacing a damaged motor. At present many decisions to repower are in part motivated by the resultant opportunity to convert from gasoline to diesel engines. It is generally accepted that diesel engines not only require less maintenance and repair but also are more economical to operate (cheaper fuel and better mileage), a factor well worth considering in view of the current energy crisis and its implications for the future.

In the process of deciding whether or not to rebuild or repower, the following factors should be considered.

1. The current condition of a vehicle, together with its anticipated future usage and the availability of parts for future repairs, indicate how much longer it can be expected to function after an overhaul. If the vehicle in question is nearing the end of its expected life, it may be preferable not to repair it, but instead to utilize in its place a vehicle from the reserve fleet until a new replacement vehicle is obtained.

2. In many cases, older inoperative vehicles are more valuable as sources of cannibalized parts than as "decrepit" pieces of apparatus requiring extensive repairs. In fact, such a vehicle may provide the only source of parts for maintaining other vehicles in the fleet.

3. When a department's current equipment lacks certain new design improvements, e.g. enclosed cabs, heavier chassis for carrying additional equipment, etc., the advantages offered by a new replacement vehicle with these features can outweigh the dollar savings associated with rebuilding an older vehicle.

4. The extent to which the age of older vehicles has detrimental effects on department morale and insurance ratings must be considered. Some departments, fearing insurance penalties, do not keep older vehicles even though they feel capable of maintaining them in first line condition. In other departments, using only the most up-to-date apparatus available is considered of paramount importance to both the fire department and the community.

B. Data and Analysis. Some form of information and analysis is used in every decision process. Often the analysis is not conscious and the information simply consists of recollections of past events, e.g. trips to the maintenance shop. If the number of vehicles is small and the replacement decision does not require formal justification, then perhaps this informal type of decision process is sufficient. As the number of vehicles increases, however, it becomes more difficult to keep mental records on each individual vehicle. Furthermore, concrete data and formal analysis can certainly be useful when justifying to others the development or revision of a replacement policy.

Before continuing, it is important to distinguish between "data" and even the most carefully kept "records". the term "records" is used here to refer to a written history of events, usually organized for ease in recording. Sometimes records are organized for each vehicle or for each company. Sometimes they are simply a chronological list of jobs completed at the maintenance shop, with the vehicle or company noted, but not organized by vehicle or company. The term "data", however, will refer to information which can be readily retrieved and is in a form organized to aid in answering the particular questions posed. A simple example: even if there is a detailed and accessible log of all repairs for each vehicle, including dates, down time, odometer readings, and cost of parts and labor, it is still no easy chore to determine whether or not the repair cost over time of, for example, clutches or the transmission for a particular vehicle, has been excessive relative to that for other similar vehicles. It is not that such a question couldn't be answered, but rather that the effort required discourages raising of the question. Yet this is precisely the type of question which should be raised in deciding whether and what to replace. It is interesting that although almost every fire department has records, some of them extremely well kept, the type of data described above was not found in any department contacted. Perhaps justifications supported by data are not as yet so necessary, or perhaps the time and cost of assembling data are felt to outweigh the likely value. Certainly, so long as the majority of records are kept by hand, the labor needed to maintain and utilize comprehensive data will remain inhibiting.

Without attempting a complete treatment, we present next a description of the kinds of data and analysis that would be needed to establish a full basis of evidence for a rational replacement decision for even a single vehicle. First, the past history of maintenance and repair costs would need to be known. These costs include parts, labor, and amortization of the maintenance facility where applicable. (If maintenance and repairs are handled by an outside facility then the cost is simply the charges incurred. If, however, repairs and maintenance are performed by the fire department itself, then the cost of operating the maintenance facility, staff, and equipment must be included.) Based on the

past records for the vehicle in question as compared to those for other similar vehicles, future maintenance and repair costs as well as down time must be projected. Also needed is an estimate of the analogous future costs if a new vehicle should be purchased. A conscientious effort to arrive at any of these figures can be a complex matter involving judgments, approximations, and (sometimes gross) simplifications. Even these are only part of what is required, since the current and future cost of money, based on current interest rates and estimates of future interest and inflation rates, should also be considered. As indicated earlier, there are yet other factors to examine, e.g. insurance ratings, and the possibility of rebuilding the vehicle. Finally, vehicles cannot be considere as totally independent entities, and their replacements may not be identical. Rather, each vehicle is a part of the fleet and willingness to replace it depends somewhat on the overall condition of that entire fleet. As mentioned previously, the economic justification for replacement may be less critical if a replacement vehicle would provide a needed extra capability.

A further factor that influences replacement policy is the pride and esprit de corps characteristic of fire departments throughout the country, and the constant desire to maintain this high level of morale. Surprisingly, these factors manifest themselves in seemingly contradictory ways. Whereas one fire department may wish to keep its vehicles as long as possible, reflecting the strength of its maintenance capabilities, other departments opt for the newest and most sophisticated apparatus, showing how up-to-date they are. Both philosophies of vehicle replacement seem to have proven successful in keeping morale high.

In practice, analysis of the factors described above has rarely been attempted, and probably justifiably so under past circumstances. Collecting data and undertaking analysis are time consuming and costly tasks distant from the interests and talents that motivate a career in the fire services. Lacking even that portion of the data that does not require prediction, an analyst would be forced to rely on assumptions and judgments which could easily be rejected by those with different opinions.

Even the most elaborate replacement policies in use today were not developed through the analysis of factors such as those described above. Where analysis has been attempted, historical records have been inadequate so that estimates about the past and future of vehicles are not firmly based on data. The resulting policies then are merely rough guidelines in the form of upper limits on dollar amounts of maintenance costs, and/or time limits on age, before replacement. Such guidelines must, of course, be tempered by subjective judgments, e.g. a newly repowered vehicle with a large repair cost recently added to its ledger would not be replaced simply because the total maintenance cost had just exceeded its prescribed upper limit.

In this discussion one final point should be made about comparing different replacement policies. Implicit in the current practice of describing a replacement policy in terms of the ages of the oldest pumpers and trucks, is the assumption that age reflects the most relevant characteristics of the vehicle, i.e. its general condition and the modernity of its features. This assumption, however, is not always true. In departments capable of rebuilding vehicles, the up-to-date features may be incorporated in older vehicles. Furthermore, "condition" itself is related to several other factors in addition to age: the quality of the vehicle when purchased originally, the amount and type of usage, the quality of preventive maintenance and repair, etc. Of these factors, only the amount of usage is readily quantifiable and easily identified. In practice, however, it is the age of a vehicle, a characteristic entirely predictable but only imperfectly indicative of usage,[8] which is used to describe a replacement policy. Because the replacement-demanding vehicle conditions and features conveniently summarized by "maximum age" are not generally stated explicitly, caution must be exercised by those inclined to justify their own "age based" replacement policy by pointing to a similar policy in existence elsewhere, where conditions may be quite different.

---

[8] Rotation of vehicles is useful to equalize usage so that age does, to some extent, imply usage within a single department. If vehicles are rotated, it is essential to keep both usage and maintenance records by vehicle rather than, or in addition to, records organized by company.

C. Maintenance. The nature of the maintenance provided is a factor vitally affecting replacement decisions. With better maintenance, vehicles can be expected to last longer. However, in determining a sound maintenance-replacement policy, a department should compare the costs and benefits of providing less maintenance and replacing vehicles sooner with those having more maintenance and delaying replacement.

The type of maintenance facility which is used impacts on replacement policy through its effects on costs. There are three major types of such facilities: (i) those wholly operated by the fire department, (ii) those operated by the city for the maintenance of all city vehicles, and (iii) commercial garages which handle fire vehicle repair on some type of contractual basis. The second category can be further divided into facilities in which the fire department maintains its own staff of mechanics, and those in which all city vehicles are repaired by the same crews. In the first category, some specialized types of repair work (e.g. radiators, body work, etc.) may be sent to commercial establishments. Each category displays wide variation in that some maintenance facilities are capable of virtually building an entire vehicle, while others have relatively meager capability. It should be noted that the traditional practice of fire departments performing their own maintenance and repairs, with their own staff, takes advantage of the direct interest, motivation, and esprit de corps in a highly dedicated service. Employees in a citywide facility may not be as well motivated, but such facilities often do allow economies of scale in their operation. Furthermore, as cities grow larger and as vehicles become more complex, the maintenance-repair job becomes larger, more technical, and farther removed from fire fighting. Thus the personal dedication of the traditional fire department maintenance facility becomes harder to retain.

A number of fire departments expressed concern over the current and future state of fire vehicle maintenance. One of the most frequently mentioned causes of concern is the number of authorized maintenance personnel. Fire departments are growing; more vehicles and other equipment are in use and require maintenance and repair. In addition, newer vehicles are often more complex than older ones and require more time to repair. This increased work-load on a fixed-size maintenance facility means that some of the work done in the past is now either not done at all or not done as well. For some departments this implies that less time can be spent fabricating parts or rebuilding vehicles, thus creating greater dependence on the ability to purchase parts when needed and an increase in the tendency to replace vehicles which formerly would have been repaired. In other departments the increased workload has led to less time being spent on preventive maintenance. Obviously the options involved in this problem include (i) increasing the maintenance facility staff, (ii) replacing vehicles and other equipment sooner because staff is not available to make certain repairs, and (iii) maintaining the status quo, realizing that with less preventive maintenance, reliability is likely to decline. (This last alternative is generally regarded by fire departments as unacceptable.) It was recommended by several departments that nationwide guidelines on the size of maintenance staff relative to fleet size would be useful in determining the adequacy of maintenance staffs for various levels of repair and maintenance capability.

A related problem in the area of maintenance is the difficulty some fire departments experience in attracting and retaining highly qualified mechanics. This was especially true of several of the maintenance facilities in which it is common practice to machine parts not otherwise available, a skill apparently rare among younger mechanics. Many departments currently offer specialized training to mechanics, and the possibility of expanding this training should be explored.

D. Availability of Parts. In discussions with fire departments across the country, problems in obtaining parts were cited continually. Many incidents involving a lack of parts were recounted. One such incident involved new vehicles which had been delivered but could not be placed in service because certain parts were not available from the manufacturer's supplier. The fire department suffers in that the vehicles are of no use to them; the manufacturer suffers because vehicles will not be paid for until they can be put into operation. More frequent than this extreme case were stories of ten to twenty year old vehicles which had to be kept out of service for long periods of time awaiting the arrival of ordered parts. Because fire fighting vehicles are expected to last for

a long time (relative to commercial trucks), it is important that spare parts be available throughout the relatively long time span. Yet, most fire vehicle manufacturers are very small relative to the auto-making firms, so that maintaining an extensive inventory of spare parts over so many years is an expensive burden for them. Furthermore, the present general shortage of raw materials is affecting the availability of many items.

There are at least two possibilities for improving the parts situation. First, any standardization of parts would be extremely helpful. Second, as suggested by several fire departments, a nationwide information clearinghouse for spare parts could be established. (A similar facility reportedly operates to the advantage of truckers stranded on highways.) Currently, when a department needs a part which is unavailable from the manufacturer or his suppliers, the fire official charged with the repair will make telephone calls -- usually on a random basis -- throughout the country trying to find another department which has the needed part and is willing to sell or trade it. The general idea of such a clearinghouse is that fire departments would submit and subsequently update lists of spare parts which they would be willing to sell or trade to other departments. An old vehicle being sold for scrap, perhaps the last of its kind in a particular fleet, may have parts which are badly needed in some other department, yet at present these parts are seldom salvaged. Although the details of such a plan would have to be worked out, it certainly appears to warrant further consideration.

IV. THE REPLACEMENT PROCESS

This section of the report is concerned with the process of replacing a vehicle once the decision to replace has been made. That process includes the following steps:

(i) deciding what type of replacement vehicle is desired,
(ii) obtaining a commitment of funds for the purchase,
(iii) writing specifications,
(iv) awarding contracts, and
(v) acceptance testing the delivered vehicle.

A. Custom Versus Commercial. The terms "custom" and "commercial" are frequently used as descriptors of fire vehicles. Because definitions for these terms vary with the opinions and experiences of the various fire departments, it is easier to explain their usage by describing some of the characteristics ascribed to vehicles in each class. For example, "custom" sometimes refers to fire vehicles with chassis built exclusively for fire vehicle use. "Commercial", on the other hand, refers to chassis produced by the large automotive manufacturers for multiple uses, of which fire vehicles are but one. There is sometimes the implication that commercial vehicles are produced "assembly-line style" with only superficial customizations available. The corresponding implication is that custom vehicles are built "from scratch" to meet the specific requirements of each individual fire department. An associated inference is that custom vehicles must be described through a very detailed set of specifications, whereas commercial vehicles could just as well be ordered by model number. Although these characterizations may not provide an entirely accurate picture of the differences between custom and commercial fire vehicles, they do convey the general attitudes with which many fire departments view the distinction.

The opinion of the majority of fire departments contacted in this study is that "custom" vehicles are far superior to "commercial" vehicles. Many departments which have or have had commercial vehicles have resolved to buy only custom vehicles from now on. The general feeling is that fire vehicles with commercial chassis "just don't stand up as well." There are, however, departments which like and buy the commercial vehicles. This is partly (but not exclusively) because they are cheaper or because maintenance and repair service is then available through local automobile service centers. Opinions were divided as to whether parts were more readily available for commercial or for custom makes.

The important issue in buying fire vehicles is, of course, that the purchased vehicle be capable of performing the required jobs for an appropriate period of time. If a lower quality vehicle can be purchased at considerable savings and can perform well for some reasonable period of time, it may be cost effective to purchase such a vehicle and plan to replace it sooner than would be necessary for a superior one. Furthermore, a vehicle said not to last long enough in one city may enjoy an entirely adequate life-span in an area where there are fewer alarms or in another city where there are fewer hills, milder climate, or a shorter replacement period. However, in a heavy-duty environment where vehicles must, for some reason, be kept for a long time, it is certainly wise to insist on purchasing the most durable vehicles available. And, in those cities where funds can be obtained, it is not uncommon to buy only "the best there is", since the additional reliability of and departmental pride in these vehicles compensates for the additional expense.

B. Specifications. To insure that a vehicle will be capable of performing as desired, fire departments write purchase specifications ("specs"). But even with the aid of the National Fire Protection Association Pamphlet Number 19, Automotive Fire Apparatus [3], many departments still feel they lack sufficient technical information and mechanical background to develop good specs for their own needs. Some large departments which purchase vehicles at frequent regular intervals have personnel specifically assigned to the job of writing specs, and may have an up-to-date set of specs readily available at all times. But for smaller departments, though, the task of writing specs can be awesome, and frequently they must call upon city engineers and the local sales representatives for assistance. In either case a great deal of time and effort is involved in writing specs, and there is no real assurance that the result actually does specify an appropriate vehicle or that the written specs truly succeed in describing the vehicle they are intended to describe.

There are actually two steps involved in preparing specs: deciding on an appropriate vehicle, and describing that vehicle in the specs. Determining that a vehicle is appropriate requires evaluation of the vehicle in terms of how well it meets the needs of the department. Because specs are now written in fairly extensive detail, proper evaluation requires up-to-date knowledge of individual components and understanding of how they function in relation to the vehicle as a whole. Having conceptualized an appropriate vehicle, a written description of it must then be prepared. At present, many specifications explicitly require features which seemingly should go without saying, for example, this extract from [3], "The engine oil fill pipe shall be large enough and so located as to permit easy filling." Such a statement is probably included as a result of previous unpleasant experiences with vehicle designs which made adding oil a difficult chore. That lack of sufficient detail in the specifications has had serious implications is illustrated by the following "horror story" recorded during our interviews. One department found that a new pumper could not achieve the specified pumping capability. The manufacturer pointed out in response to the department's complaint that the pumper had successfully passed tests conducted at sea level, and no qualification as to altitude had been included in the specs.

Another factor complicating the task of spec writing is that it is not sufficient to specify a level of performance: to be complete, specs should also require a long duration for that performance. Thus purchasers specify, for example, a particular grade or thickness of material because this is apparently the only way to attempt to guarantee in advance the maintenance of a particular performance level over many years. (Lack of this kind of specification is sometimes used as a characterization of the so called "commercial" vehicles.) Knowing what materials are available and desirable requires either a time-consuming effort at keeping abreast of current technology or else further dependence on sales representatives to help write specs.

One possibility for reducing some of the burden of spec writing is the adoption of standard industry-wide "basic" vehicles for each of several usage categories, for example, light, average, and heavy. Specifications for these basic vehicles might be drawn up by a committee composed of representatives from fire departments and fire vehicle manufacturers. Approval of the specs by the NFPA might be sought. Once these basic specifications are properly documented, fire departments could then prepare most of their vehicle-descriptions simply by citing these documented specs, giving detailed specs only for deviations from the standard. The concept here is the seemingly contradictory one of providing "customized standard" vehicles.

In addition to facilitating the job of writing specs, the formulation of such standard basic vehicles may prove beneficial in other ways. To the extent that virtually identical vehicles would be requested by many fire departments, manufacturers may be able better to anticipate the demand for their products and to take advantage of economies of scale so as to produce these standard vehicles at lower cost. Shorter delivery times may be possible than are now experienced for the same vehicles without the philosophy of standardization. Furthermore, since the basic vehicles would be experiencing widespread use, features which are undesirable should be more readily noticeable so that the specs could be revised to incorporate the indicated changes. This should result in greater assurance of the requested vehicle's being appropriate for the anticipated duty. Still another advantage is the possibility of developing acceptance tests specifically designed for each standard vehicle. (This possibility will be discussed in more detail later.)

There are also benefits for any fire department desiring non-standard specs or innovations. New ideas could be presented through a designated committee or organization for nationwide distribution and comments. Even if such ideas were not accepted for incorporation into the standards, those departments supporting the idea could then approach the manufacturers and bargain as a group in order to spread the amortization costs more evenly among the interested departments. With the cost of requesting nonstandard items thus reduced, new or "special" items could be put into use more easily and quickly.

C. Budget Considerations. Which type of budgeting is employed is determined by the city's governmental structure, and can greatly influence how much leeway a department has in deciding how to use the money allotted to it. Generally funds for capital equipment are provided either through bond issues, or in a separate capital budget, or as part of an operating budget. When funds are dependent on bonds, there can be extraordinary time constraints on replacement because the pre-order lead time is greatly extended. Some localities restrict the use of bond money, so that expenditures must be made as soon as the funds are available. Other areas stipulate that vehicles can not be replaced until the bonds financing their purchase have been paid off, and so the vehicles must be kept in service until then.[9] (A community enforcing such restrictions on its fire department should be aware that it is in effect removing a large part of the replacement decision from the hands of the officials most knowledgeable on the subject.)

Justification for funds may be required at different levels of detail. Here again (cf. p. 6) data, as opposed to records, may be important since people farther removed from a vehicle may be less inclined to make subjective decisions about replacing it, and may not share (or necessarily trust) the intuitive perceptions of those "on the front line".

As the budgeting process becomes more formal it may behoove a fire department to have built into its budget a fixed level of replacement, e.g. so many pumpers and/or trucks to be replaced each year. With an established policy such as this, a department will have less difficulty obtaining a minimum number of vehicles. The reasonability of such a policy depends on several factors. If a city is changing in any substantial way (e.g. annexation, population explosion, urban renewal featuring highrise buildings, etc.), this should be considered in forming the policy. Also to be considered is the current condition of the inventory. Clearly, if the fleet is basically new then such a policy is not reasonable. On the other hand, if the fleet is currently old there may not be enough time to spread out the replacement of vehicles over a number of years. If a fixed-level policy is to be instituted, then it is important to choose it carefully since by its very nature such a policy should not require annual reformulation. Many fire departments are using or starting to use such a policy, and the tendency is toward shorter replacement cycles. Although there are cities in which shorter cycles are called for, it is not clear that every department aiming for a shorter replacement cycle is really justified in that objective, or has seriously considered all of the alternatives in order to be certain that the shorter cycle really represents the best possible decision.

D. Acceptance Testing and Evaluation. In many areas it is standard practice (and often a legal requirement) for all new vehicles to be acceptance tested prior to being placed in active service. The primary aim of such tests is to insure that the delivered vehicle meets the specs. Devising and executing good tests can be a costly and time consuming process, particularly if some new technology is involved for which adequate tests may not yet be established. It is likely that numerous departments across the country are executing the same tests on virtually identical vehicles, with neither the test procedures nor the results generally made available to other departments.

There are several immediately obvious ideas worthy of further exploration in the area of testing. First is the idea that both the procedures and the results of local departmental tests be made available to other departments. Knowledge of test procedures used elsewhere could help a department in establishing or modifying its own procedures. Knowledge of the results obtained elsewhere would help the decision process in departments which may be considering purchase of a similar vehicle. Also, comparing the results obtained by several different departments could reveal areas in which more definitive specs are necessary, e.g. the need to specify the altitude at which a specific pumping capability must be achieved.

---

[9] If the bond issue is for a sum of money to be used for replacement as necessary over the time frame of the issue, without restriction as to how long the vehicles must be utilized, then the bond money is very similar to an annual capital budget.

Another idea is that of establishing standard acceptance tests developed specifically for the proposed basic vehicles described earlier in this section. As indicated in the previous paragraph, the existence of standard tests for a particular vehicle type would lessen the need for locally devised testing procedures and would permit direct comparison of test results obtained by numerous departments. If a particular vehicle type were not performing well in some specific test, a significant amount of data would be available both to back up the observation and to indicate to the manufacturer the extent of the problem.

Although some information on acceptance testing is included in Pamphlet 19 of the NFPA[10], Automotive Fire Apparatus, many fire departments have expressed a need for further guidance in this area. The NFPA Committee on Fire Department Equipment, which prepares Pamphlet 19, might act on these needs. Alternatively, there may be need for a national center devoted to the establishment of sound test procedures. Such a center would accept responsibility for publicizing test procedures and results submitted by fire departments, as well as establishing detailed test procedures for the proposed basic vehicles and for new technology. Although no external group can completely relieve a fire department of the responsibility for acceptance testing its own equipment, it is hoped that follow-up efforts on these suggestions might help to lighten the testing burden under which many departments now labor.

---

[10] National Fire Protection Association.

V. SUMMARY AND RECOMMENDATIONS

Our aim in this report has been to present and build upon the thoughts of fire departments regarding various issues and problems relating to vehicle replacement. Although, as mentioned previously, comments were not solicited from either city management officials or vehicle manufacturers, it is clear from the departments alone that there is no one "vehicle replacement problem," nor is there a single answer to any one of the more specific problems that exist. There is, however, a single logical approach to problem solving, namely that of considering a variety of alternatives and making a reasoned choice from among them. This approach requires a thorough knowledge of the local situation, including the ability to distinguish those procedures which are rigid or highly resistant to change from those in which there is some flexibility and room for improvement. Data and analysis to support a particular argument may become increasingly important in the future if others are to be convinced of the need for changes.

Considering all alternatives requires first knowing what alternatives exist. To this end, improved communications among departments are imperative. In many organizations new ideas, information, and channels of communication accompany personnel who transfer between the particular group and other similar ones, frequently to obtain higher salaries or positions. The traditional fire department practice of promoting vertically from within the ranks discourages lateral transfers of personnel from other departments, thereby eliminating at least one common medium for communication. Although the practices of one department are not in general best for all, knowledge of what other departments are doing will at the very least reveal additional alternatives, and may actually provide useful new techniques.

Communications among departments should be expanded at all levels of the fire service. In the interviews conducted during this study, fire officials stressed that the pamphlets and journals of the NFPA are valuable, as are the numerous meetings and conventions they attend in order to exchange views on many aspects of fire department operation. However, this simply is not enough. There should be journals and reports aimed, for example, at maintenance shop foremen, where problems, issues, and solutions specific to this particular area of fire service can be readily presented and discussed. In the course of the study many incidents were related to our staff in which a particular department had spent much time and effort deliberating about a problem such as the purchase of some new equipment (e.g. a new fabric for turnout coats), or developing a new technique (e.g. a different way to dry hose), only to learn much later that other departments, sometimes nearby ones, had earlier gone through the same process. During our visit to one department, the head of the maintenance facility explained that he had installed a thermostat in some pumpers so that the fan belt and cooling system did not operate until a certain temperature was reached, in order to provide extra motor power on short runs (especially desirable in hilly areas). In a later interview with another department, a member of the project staff repeated this story. The fire chief being interviewed immediately discussed the idea with his maintenance chief and on the spot they jointly decided it was an idea worth trying in their own vehicles. Perhaps something as simple as periodic newsletters, containing information, reports, and suggestions solicited from all departments and distributed to all departments, for various aspects of the fire service, could prove a valuable asset to everyone concerned.

In the same general vein of improving interdepartmental communications are the recommendations, earlier in this report, for a national clearinghouse for spare parts, nationally accepted performance standards for vehicles at various levels of usage, and standards for determining minimum staffing requirements at maintenance shops for various levels of fleet size, maintenance, and repair. Again, in order to be useful, these suggestions must be developed in detail and widely supported by members of the fire service.

One of the opportunities and responsibilities of the National Fire Prevention and Control Administration might well be to support such efforts, to assist fire departments nationwide to develop a clearinghouse for all kinds of useful information (including reports on testing and implementation of new technology), and to provide a forum in which to discuss and define standards in all areas of the fire service. This agency could also find it natural to offer help in the areas of data collection and analysis, showing fire departments

what types of data can be useful and assisting in the implementation of adequate data collection and analysis procedures. Decisions made on the basis of greatly expanded data (both local and national), together with some general guidelines, would in all likelihood be distinctly superior to those currently being made.

On the other hand, fire departments of various sizes in various parts of the country have vastly different problems, so that very few, if any, hard and fast rules can be formulated. The dividing line between rules and guidelines or standards can be very fine. Nothing in this report should be construed as implying any intention to pry the power of decision away from the local level. There is a great deal of pride and a sense of unique identity in local fire departments, and efforts to "help" would backfire should they corrode this feeling which is so vital to the performance of the organization.

To conclude, the principal recommendations arising from this study are recapitulated in list form.

On the local level:

(1) Expand efforts to determine what other fire departments are doing, including problems encountered and "solutions" attempted.

(2) Publicize operational procedures, including problems and the approaches tried for solving them. Disseminate information about what has worked as well as what hasn't so that others can follow recommendations and heed warnings.

(3) Consider alternatives to current or traditional administrative procedures and organization. The alternatives may prove preferable to the present system, they may be the only solution when unprecedented situations arise, e.g. a budget squeeze coinciding with increased demand for fire protection, and even if rejected, the evidence that alternatives have been considered and the reasons given for rejection will strengthen the case for not adopting them.

These local recommendations require national-level efforts to facilitate the processes of (1) finding out what other departments are doing, (2) publicizing procedures, and (3) determining what alternatives exist for consideration. This report has discussed several possibilities for improving communications and has given a number of ideas indicative of the broad spectrum of administrative and organizational policies currently in use. Undoubtedly many other alternatives exist, and will become apparent if the channels of communication among departments are more firmly established. All of the national-level recommendations presented below for consideration by the National Fire Prevention and Control Administration imply improved communications and will establish channels through which departments can share their experiences in many aspects of the fire service.

On the national level:

(1) Establish an organization (or utilize one which already exists) devoted to improving communications among departments about all aspects of the fire service.

(2) Establish a national clearinghouse for spare parts.

(3) Establish nationally accepted performance standards for vehicles in various usage categories.

(4) Establish standards for determining minimum staffing requirements at maintenance shops for various levels of fleet size, maintenance, and repair.

(5) Explore the possibility of establishing national or regional centers for training fire service personnel (e.g., courses for fire vehicle mechanics) and for establishing tests on vehicles and other equipment.

Although our recommendations have been summarized separately under the categories of "local" and "national", the success of any or all of them requires participation by many local departments. Obviously, no one fire department can single-handedly undertake any of the tasks listed above. But at the same time, no one fire department agreeing with these recommendations can afford to sit back and assume that others will institute the programs. Support for these ideas should be verbalized at every opportunity, to secure the level of participation which is essential as the tasks are undertaken.

ACKNOWLEDGEMENTS

The authors wish to thank the many fire department officials across the country who generously contributed their time and insights in discussing the subject of the report with members of the project staff. Their cooperation was an essential ingredient in this study. The assistance, suggestions, and editorial review provided by A. J. Goldman and W. A. Steele of the Applied Mathematics Division are greatly appreciated.

VI. REFERENCES

1. Saunders, P. B. and Ku, R., "Sequencing the Purchase and Retirement of Fire Engines", Fire Safety Research, NBS Special Publication 411, Nov. 1974, pp. 201-214.

2. Municipal Fire Administration, International City Managers' Association, 1967, pp. 128-157.

3. Automotive Fire Apparatus, National Fire Protection Association Pamphlet No. 19, 1973.

4. "Fire Equipment Management", Urban Data Service Report, Vol. 4 No. 12, International City Management Association, December 1972.

5. Saunders, P. B., A Computer Model for Simulating the Response Activities of a Fire Department, unpublished report, September 1971.

NBS-114A (REV. 7-73)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBS TN-891	2. Gov't Accession No.	3. Recipient's Accession No.

4. TITLE AND SUBTITLE

Issues in Fire Vehicle Replacement: Users' Views and Synthesis

5. Publication Date: January 1976

6. Performing Organization Code

7. AUTHOR(S)
P. B. Saunders, R. H. F. Jackson, P. R. Meyers, M. H. Pearl

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)*

13. Type of Report & Period Covered

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report documents the findings and recommendations from a study of fire vehicle replacement procedures. Exploration of that subject proved to require consideration of related issues arising in: (1) writing apparatus specifications, (2) maintaining and repairing vehicles, and (3) obtaining spare parts. The topics and most of the recommendations described herein are synthesized directly from visits and/or telephone interviews with fire department officials across the country. The recommendations of the study call for greatly increased communication among departments, the development of standards for vehicle performance, maintenance staff size, etc., and national and/or regional centers for training personnel and establishing standard vehicle testing procedures.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Engine pumper; fire vehicle; ladder truck; maintenance; replacement; specifications; standards.

18. AVAILABILITY

[X] Unlimited

[ ] For Official Distribution. Do Not Release to NTIS

[X] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13. 46:891

[ ] Order From National Technical Information Service (NTIS) Springfield, Virginia 22151

19. SECURITY CLASS (THIS REPORT)	21. NO. OF PAGES
UNCLASSIFIED	19
20. SECURITY CLASS (THIS PAGE)	22. Price
UNCLASSIFIED	$1.10

USCOMM-DC 29042-P

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH reports National Bureau of Standards research and development in physics, mathematics, and chemistry. It is published in two sections, available separately:

• **Physics and Chemistry (Section A)**

Papers of interest primarily to scientists working in these fields. This section covers a broad range of physical and chemical research, with major emphasis on standards of physical measurement, fundamental constants, and properties of matter. Issued six times a year. Annual subscription: Domestic, $17.00; Foreign, $21.25.

• **Mathematical Sciences (Section B)**

Studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems. Short numerical tables. Issued quarterly. Annual subscription: Domestic, $9.00; Foreign, $11.25.

DIMENSIONS/NBS (formerly Technical News Bulletin)—This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

Annual subscription: Domestic, $9.45; Foreign, $11.85.

NONPERIODICALS

Monographs—Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Applied Mathematics Series—Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a world-wide program coordinated by NBS. Program under authority of National Standard Data Act (Public Law 90-396).

NOTE: At present the principal publication outlet for these data is the Journal of Physical and Chemical Reference Data (JPCRD) published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements available from ACS, 1155 Sixteenth St. N. W., Wash. D. C. 20056.

Building Science Series—Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. NBS administers this program as a supplement to the activities of the private sector standardizing organizations.

Federal Information Processing Standards Publications (FIPS PUBS)—Publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

Consumer Information Series—Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

NBS Interagency Reports (NBSIR)—A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Service (Springfield, Va. 22161) in paper copy or microfiche form.

Order NBS publications (except NBSIR's and Bibliographic Subscription Services) from: Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

BIBLIOGRAPHIC SUBSCRIPTION SERVICES

The following current-awareness and literature-survey bibliographies are issued periodically by the Bureau:

Cryogenic Data Center Current Awareness Service

A literature survey issued biweekly. Annual subscription: Domestic, $20.00; foreign, $25.00.

Liquefied Natural Gas. A literature survey issued quarterly. Annual subscription: $20.00.

Superconducting Devices and Materials. A literature survey issued quarterly. Annual subscription: $20.00. Send subscription orders and remittances for the preceding bibliographic services to National Technical Information Service, Springfield, Va. 22161.

Electromagnetic Metrology Current Awareness Service Issued monthly. Annual subscription: $24.00. Send subscription order and remittance to Electromagnetics Division, National Bureau of Standards, Boulder, Colo. 80302.

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

OFFICIAL BUSINESS

Penalty for Private Use, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215

SPECIAL FOURTH-CLASS RATE
BOOK